

1 What is claimed is:

2

3 1. In a file server system having a clock for producing a clock time and a processor
4 for servicing client requests for access to a file, the processor having a timer for
5 measuring a time interval, a method comprising:

6 the processor obtaining the clock time from the clock, and beginning
7 measurement of the time interval with the timer, and

8 the processor responding to a request from a client for an asynchronous write to
9 the file by performing an asynchronous write operation with respect to the file, and
10 determining a file-modification time that is a function of the clock time having been
11 obtained from the clock and the time interval measured by the timer, the file-modification
12 time indicating a time of modification of the file by the asynchronous write operation.

13

14 2. The method as claimed in claim 1, wherein the file-modification time is a sum of
15 the clock time having been obtained from the clock and the time interval measured by the
16 timer.

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18 3. The method as claimed in claim 1, which includes the processor acknowledging
19 the request from the client for an asynchronous write to the file by returning to the client
20 the file-modification time.

21

22 4. The method as claimed in claim 1, which further includes the processor receiving
23 an updated value for the file-modification time after the processor has determined a value

1 for the file-modification time, the processor comparing the updated value to the value that
2 the processor has determined for the file-modification time, and upon finding that the
3 updated value for the file-modification time is greater than the value that the processor
4 has determined for the file-modification time, then the processor resetting the timer and
5 using the updated value for the file-modification time in lieu of the clock time obtained
6 from the clock.

7
8 5. The method as claimed in claim 4, wherein the processor stores the clock time
9 having been obtained from the clock in a memory location local to the processor, and the
10 processor uses the updated value for the file-modification time in lieu of the clock time
11 obtained from the clock by replacing the clock time having been obtained from the clock
12 and stored in the memory location local to the processor with the updated value for the
13 file-modification time.

14
15 6. The method as claimed in claim 1, which further includes the processor receiving
16 an updated value for the file-modification time after the processor has determined a value
17 for the file-modification time, the processor comparing the updated value for the file-
18 modification time to the value that the processor has determined for the file-modification
19 time, and upon finding the updated value for the file-modification time is less than the
20 value that the processor has determined for the file-modification time, then the processor
21 ignoring the updated value for the file-modification time.

22

1 7. In a file server system having a first processor and a second processor for
2 servicing client requests for access to a file, the first processor having a clock producing a
3 clock time, and the second processor having a timer for measuring a time interval, a
4 method comprising:

5 the second processor responding to a first request from a client for an
6 asynchronous write to the file by obtaining the clock time from the clock of the first
7 processor, beginning measurement of the time interval with the timer, performing a first
8 asynchronous write operation with respect to the file, and using the clock time obtained
9 from the clock of the first processor as a first file-modification time, the first file-
10 modification time indicating a time of modification of the file by the first asynchronous
11 write operation; and thereafter

12 the secondary processor responding to a second request from the client for an
13 asynchronous write to the file by performing a second asynchronous write operation with
14 respect to the file, and determining a second file-modification time that is a function of
15 the clock time obtained from the clock of the first processor and the time interval
16 measured by the timer, the second file-modification time indicating a time of
17 modification of the file by the second asynchronous write operation.

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19 8. The method as claimed in claim 7, wherein the file-modification time is a sum of
20 the clock time having been obtained from the clock and the time interval measured by the
21 timer.

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1 9. The method as claimed in claim 7, which includes:
2 the second processor acknowledging the first request from the client for an
3 asynchronous write to the file by returning to the client the first file-modified time for the
4 file; and
5 the second processor acknowledging the second request from the client for an
6 asynchronous write to the file by returning to the client the second file-modified time for
7 the file.

8
9 10. The method as claimed in claim 7, which includes the second processor
10 responding to a request from the client to commit results of the second asynchronous
11 write operation by sending the second file-modification time to the first processor.

12
13 11. In a file server system having a first processor and a second processor for
14 servicing client requests for access to a file, the first processor having a clock producing a
15 clock time, and the second processor having a timer for measuring a time interval, a
16 method comprising:

17 the second processor responding to a first request from a client for an
18 asynchronous write to the file by obtaining the clock time from the clock of the first
19 processor, beginning measurement of the time interval with the timer, performing a first
20 asynchronous write operation with respect to the file, and using the clock time obtained
21 from the clock of the first processor as a first file-modification time, the first file-
22 modification time indicating a time of modification of the file by the first asynchronous
23 write operation; and thereafter

1 the second processor receiving from the first processor an updated value for the
2 file-modification time, the second processor comparing the updated value for the file-
3 modification time to the first file-modification time, and upon finding that the updated
4 value is greater than the first file-modification time, the second processor resetting the
5 timer; and thereafter

6 the second processor responding to a second request from the client for an
7 asynchronous write to the file by performing a second asynchronous write operation with
8 respect to the file, and determining a second file-modification time that is a sum of the
9 updated value for the file-modification time and the time interval measured by the timer,
10 the second file-modification time indicating a time of modification of the file by the
11 second asynchronous write operation.

12

13 12. In a file server system having a primary processor managing metadata of a file,
14 and a secondary processor responding to requests from a client for access to the file, the
15 primary processor having a clock producing a clock time, and the secondary processor
16 having a timer for measuring a time interval, a method comprising:

17 the secondary processor responding to a first asynchronous write request from the
18 client for writing to the file by obtaining attributes of the file and the clock time from the
19 primary processor, storing the attributes of the file in a cache local to the secondary
20 processor and using the file attributes to perform a first asynchronous write operation
21 with respect to the file, and beginning measurement of the time interval with the timer,
22 and thereafter

1 the secondary processor responding to a second asynchronous write request from
2 the client for writing to the file by using the attributes of the file in the cache local to the
3 secondary processor to perform a second asynchronous write operation with respect to
4 the file, and determining a file-modification time that is a function of the clock time
5 having been obtained from the clock of the primary processor and the interval measured
6 by the timer, the file-modification time indicating a time of modification of the file by the
7 second asynchronous write operation.

8
9 13. The method as claimed in claim 12, wherein the file-modification time is a sum of
10 the clock time having been obtained from the clock and the time interval measured by the
11 timer.

12
13 14. The method as claimed in claim 12, which includes:

14 the secondary processor acknowledging the second asynchronous write request
15 from the client by returning to the client the file-modification time as the time when the
16 file was modified by the second asynchronous write operation.

17
18 15. The method as claimed in claim 12, which includes:

19 the secondary processor responding to a request from the client to commit results
20 of the second asynchronous write operation by sending a flush request to the primary
21 processor, the flush request including the file-modification time.

1 16. The method as claimed in claim 15, which includes the primary processor sending
2 the file-modification time to another client caching attributes for the file.

3
4 17. The method as claimed in claim 12, which includes the secondary processor
5 receiving from the primary processor an updated value for the file-modification time after
6 the secondary processor has completed the second asynchronous write operation, the
7 secondary processor comparing the updated value for the file-modification time to the
8 last value for the file-modification time determined by the secondary processor, and upon
9 finding that the updated value for the file-modification time is greater than the last value
10 for the file-modification time determined by the secondary processor, the secondary
11 processor resetting the timer, and using the updated value for the file-modification time in
12 lieu of the clock time having been obtained from the primary processor, and using the
13 updated value for the file-modification time as the most recent value of the file-
14 modification time.

15
16 18. The method as claimed in claim 12, which includes the secondary processor
17 receiving from the primary processor an updated value for the file-modification time after
18 the secondary processor has completed the second asynchronous write operation, the
19 secondary processor comparing the updated value for the file-modification time to the
20 last value for the file-modification time determined by the secondary processor, and upon
21 finding that the updated value for the file-modification time is less than the last value for
22 the file-modification time determined by the secondary processor, the secondary
23 processor ignoring the updated value for the file-modification time.

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2 19. In a network file server having a plurality of data mover computers for servicing
3 client requests for access to a file, and a cached disk array for storing data of the file, the
4 data mover computers being coupled to the cache disk array for accessing the data of the
5 file, the data mover computers including a primary data mover computer managing
6 metadata of the file, and a secondary data mover computer that requests metadata of the
7 file from the primary data mover computer, the primary data mover computer having a
8 clock producing a clock time, and the secondary data mover computer having a timer for
9 measuring a time interval, a method comprising:

10 the secondary data mover computer responding to a first asynchronous write
11 request from a client for writing to the file by obtaining attributes of the file and the clock
12 time from the primary data mover computer, storing the attributes of the file in a cache
13 local to the secondary data mover computer and using the file attributes to perform a first
14 asynchronous write operation with respect to the file, and using the clock time as a first
15 file-modification time indicating a time of modification of the file by the first
16 asynchronous write operation; and thereafter

17 the secondary data mover computer responding to a second asynchronous write
18 request from the client for writing to the file by using the attributes of the file in the cache
19 local to the secondary data mover computer to perform a second asynchronous write
20 operation with respect to the file, and determining a second file-modification time that is
21 a function of the clock time having been obtained from the primary data mover and the
22 time interval measured by the timer, the second file-modification time indicating a time
23 of modification of the file by the second asynchronous write operation.

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2 20. The method as claimed in claim 19, wherein the second file-modification time is a
3 sum of the clock time having been obtained from the primary data mover and the time
4 interval measured by the timer.

5

6 21. The method as claimed in claim 19, wherein:

7 the secondary data mover computer uses the clock time as a first file-modification
8 time by acknowledging the first asynchronous write request from the client by returning
9 to the client the clock time as the time when the file was modified by the first
10 asynchronous write operation, and

11 the secondary data mover computer acknowledges the second asynchronous write
12 request from the client by returning to the client the second file-modification time as the
13 time when the file was modified by the second asynchronous write operation.

14

15 22. The method as claimed in claim 19, which includes:

16 the secondary data mover computer responding to a request from the client to
17 commit results of the second asynchronous write operation by sending a flush request to
18 the primary data mover computer, the flush request including the second file-
19 modification time.

20

21 23. The method as claimed in claim 22, which includes the primary data mover
22 computer sending the second file-modification time to another client caching attributes
23 for the file.

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2 24. The method as claimed in claim 19, which includes the secondary data mover
3 computer receiving from the primary data mover computer an updated value for the file-
4 modification time for the file after the secondary data mover computer has completed the
5 first asynchronous write operation, the secondary data mover computer comparing the
6 updated value for the file-modification time for the file to the last value determined by
7 the secondary data mover for the file-modified time for the file, and upon finding that the
8 updated value for the file-modification time for the file is greater than the last value
9 determined by the secondary data mover for the file-modified time for the file, the
10 secondary data mover computer resetting the timer, using the updated value for the file-
11 modification time in lieu of the clock time having been obtained from the primary data
12 mover computer, and using the updated value for the file-modification time for the file as
13 the most recent value for the file-modification time for the file.

14

15 25. The method as claimed in claim 19, which includes the secondary data mover
16 computer receiving from the primary data mover computer an updated value for the file-
17 modification time for the file after the secondary data mover computer has completed the
18 first asynchronous write operation, the secondary data mover computer comparing the
19 updated value for the file-modification time for the file to the last value determined by
20 the secondary data mover for the file-modified time for the file, and upon finding that the
21 updated value for the file-modification time for the file is less than the last value
22 determined by the secondary data mover for the file-modified time for the file; the
23 secondary data mover computer ignoring the updated value for the file-modification time.

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2 26. A file server system having a clock for producing a clock time and a processor for
3 servicing client requests for access to a file, the processor having a timer for measuring a
4 time interval;

5 the processor being programmed for obtaining the clock time from the clock, and
6 beginning measurement of the time interval with the timer, and

7 the processor being programmed for responding to a request from a client for an
8 asynchronous write to the file by performing an asynchronous write operation with
9 respect to the file, and determining a file-modification time that is a function of the clock
10 time having been obtained from the clock and the time interval measured by the timer,
11 the file-modification time indicating a time of modification of the file by the
12 asynchronous write operation.

13

14 27. The file server system as claimed in claim 26, wherein the file-modification time
15 is a sum of the clock time having been obtained from the clock and the time interval
16 measured by the timer.

17

18 28. The file server system as claimed in claim 26, wherein the processor is
19 programmed to acknowledging the request from the client for an asynchronous write to
20 the file by returning to the client the file-modification time.

21

22 29. The file server system as claimed in claim 26, wherein the processor is
23 programmed for receiving an updated value for the file-modification time after the

1 processor has determined a value for the file-modification time, comparing the updated
2 value for the file-modification time to the value that the processor has determined for the
3 file-modification time, and upon finding the updated value for the file-modification time
4 is greater than the value that the processor has determined for the file-modification time,
5 resetting the timer and using the updated value for the file-modification time in lieu of the
6 clock time having been obtained from the clock.

7
8 30. The file server system as claimed in claim 29, wherein the processor is
9 programmed for storing the clock time having been obtained from the clock in a memory
10 location local to the processor, and for using the updated value for the file-modification
11 time in lieu of the clock time having been obtained from the clock by replacing the clock
12 time stored in the memory local to the processor with the updated value for the file-
13 modification time.

14
15 31. The file server system as claimed in claim 26, wherein the processor is
16 programmed for receiving an updated value for the file-modification time after the
17 secondary processor has determined a value for the file-modification time, comparing the
18 updated value to the value that the processor has determined for the file-modification
19 time, and ignoring the updated value for the file-modification time upon finding the
20 updated value for the file-modification time is less than the value that the secondary
21 processor has determined for the file-modification time.

22

1 32. A file server system comprising:
2 a first processor and a second processor for servicing client requests for access to
3 a file, the first processor having a clock for producing a clock time, and the second
4 processor having a timer for measuring a time interval;
5 the second processor being programmed for responding to a first request from a
6 client for an asynchronous write to the file by obtaining the clock time from the clock of
7 the first processor, beginning measurement of the time interval with the timer,
8 performing a first asynchronous write operation with respect to the file, and using the
9 clock time obtained from the clock of the first processor as a first file-modification time,
10 the first file-modification time indicating a time of modification of the file by the first
11 asynchronous write operation; and the second processor being programmed for
12 responding to a second request from the client for an asynchronous write to the file by
13 performing a second asynchronous write operation with respect to the file, and
14 determining a second file-modification time that is a function of the clock time obtained
15 from the clock of the first processor and the time interval measured by the timer, the
16 second file-modification time indicating a time of modification of the file by the second
17 asynchronous write operation.

18
19 33. The file server system as claimed in claim 32, wherein the second file-
20 modification time is a sum of the clock time obtained from the clock and the time interval
21 measured by the timer.

22

1 34. The file server system as claimed in claim 32, wherein:
2 the second processor is programmed to use the clock time obtained from the clock
3 of the first processor as a first file-modification time by acknowledging the first request
4 from the client for an asynchronous write to the file by returning to the client the clock
5 time obtained from the clock of the first processor as the time when the file was modified
6 by the first asynchronous write operation, and
7 the second processor is programmed to acknowledge the second request from the
8 client for an asynchronous write to the file by returning to the client the second file-
9 modification time as the time when the file was modified by the second asynchronous
10 write operation.

11

12 35. The file server system as claimed in claim 32, wherein the second processor is
13 programmed for responding to a request from the client to commit results of the second
14 asynchronous write operation by sending the second file-modification time to the first
15 processor.

16

17 36. A file server system comprising:
18 a first processor and a second processor for servicing client requests for access to
19 a file, the first processor having a clock for producing a clock time, and the second
20 processor having a timer for measuring a time interval;
21 the second processor being programmed for responding to a first request from a
22 client for an asynchronous write to the file by obtaining the clock time from the clock of
23 the first processor, beginning measurement of the time interval with the timer, and

1 performing a first asynchronous write operation with respect to the file, and using the
2 clock time obtained from the clock of the first processor as a first file-modification time
3 indicating a time of modification of the file by the first asynchronous write operation; and
4 the second processor being programmed for receiving from the first processor an
5 updated value for the file-modification time, for comparing the updated value to the first
6 file-modification time, and upon finding that the updated value is greater than the first
7 file-modification time, for resetting the timer; and
8 the second processor being programmed to respond to a second request from the
9 client for an asynchronous write to the file by performing a second asynchronous write
10 operation with respect to the file, and determining a second file-modification time that is
11 a sum of the updated value for the file-modification time and the time measured by the
12 timer, the second file-modification time indicating a time of modification of the file by
13 the second asynchronous write operation.

14
15 37. A file server system comprising:

16 a primary processor managing metadata of a file, and a secondary processor
17 responding to requests from a client for access to the file, the primary processor having a
18 clock for producing a clock time, and the secondary processor having a timer for
19 measuring a time interval;

20 the secondary processor being programmed for responding to a first asynchronous
21 write request from the client for writing to the file by obtaining attributes of the file and
22 the clock time from the primary processor, storing the attributes of the file in a cache
23 local to the secondary processor and using the file attributes to perform a first

1 asynchronous write operation with respect to the file, and beginning measurement of the
2 time interval with the timer; and

3 the secondary processor being programmed for responding to a second
4 asynchronous write request from the client for writing to the file by using the attributes of
5 the file in the cache local to the secondary processor to perform a second asynchronous
6 write operation with respect to the file, and determining a file-modification time that is a
7 function of the clock time having been obtained from the clock of the primary processor
8 and the time interval measured by the timer, the file-modification time indicating a time
9 of modification of the file by the second asynchronous write operation.

10

11 38. The file server system as claimed in claim 37, wherein the file-modification time
12 is a sum of the clock time having been obtained from the primary processor and the time
13 interval measured by the timer.

14

15 39. The file server system as claimed in claim 37, wherein:

16 the secondary processor is programmed for acknowledging the second
17 asynchronous write request from the client by returning to the client the file-modification
18 time as the time when the file was modified by the second asynchronous write operation.

19

20 40. The file server system as claimed in claim 37, wherein the secondary processor is
21 programmed for responding to a request from the client to commit results of the second
22 asynchronous write operation by sending a flush request to the primary processor, the
23 flush request including the file-modification time.

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2 41. The file server system as claimed in claim 40, wherein the primary processor is
3 programmed to send the file-modification time to other clients caching attributes for the
4 file.

5

6 42. The file server system as claimed in claim 37, wherein the secondary processor is
7 programmed for receiving from the primary processor an updated value for the file-
8 modification time after the secondary processor has completed the second asynchronous
9 write operation, for comparing the updated value for the file-modification time to the last
10 value for the file-modification time determined by the secondary processor, and upon
11 finding that the updated value for the file-modification time is greater than the last value
12 for the file-modification time determined by the secondary processor, for resetting the
13 timer, and using the updated value for the file-modification time in lieu of the clock time
14 having been obtained from the primary processor, and using the updated value for the
15 file-modification time as the most recent value of the file-modification time.

16

17 43. The file server system as claimed in claim 37, wherein the secondary processor is
18 programmed for receiving from the primary processor an updated value for the file-
19 modification time after the secondary processor has completed the second asynchronous
20 write operation, for comparing the updated value for the file-modification time to the last
21 value for the file-modification time determined by the secondary processor, and upon
22 finding that the updated value for the file-modification time is less than the last value for

1 the file-modification time determined by the secondary processor, for ignoring the
2 updated value for the file-modification time.

3
4 44. A network file server comprising:

5 a plurality of data mover computers for servicing client requests for access to a
6 file, and a cached disk array for storing data of the file, the data mover computers being
7 coupled to the cached disk array for accessing the data of the file, the data mover
8 computers including a primary data mover computer programmed for managing metadata
9 of the file, and a secondary data mover computer programmed for requesting metadata of
10 the file from the primary data mover computer, the primary data mover computer having
11 a clock for producing a clock time, and the secondary data mover computer having a
12 timer for measuring a time interval;

13 the secondary data mover computer being programmed for responding to a first
14 asynchronous write request from a client for writing to the file by obtaining attributes of
15 the file and the clock time from the primary data mover computer, storing the attributes
16 of the file in a cache local to the secondary data mover computer and using the file
17 attributes to perform a first asynchronous write operation with respect to the file,
18 beginning measurement of the time interval with the timer, and using the clock time as a
19 first file-modification time, the first file-modification time indicating a time of
20 modification of the file by the first asynchronous write operation; and

21 the secondary data mover computer being programmed for responding to a second
22 asynchronous write request from the client for writing to the file by using the attributes of
23 the file in the cache local to the secondary data mover computer to perform a second

1 asynchronous write operation with respect to the file, and determining a second file-
2 modification time that is a function of the clock time having been obtained from the
3 primary data mover and the time interval measured by the timer, the second file-
4 modification time indicating a time of modification of the file by the second
5 asynchronous write operation.

6

7 45. The network file server as claimed in claim 44, wherein the second file-
8 modification time is a sum of the clock time having been obtained from the primary data
9 mover and the time interval measured by the timer.

10

11 46. The network file server as claimed in claim 44, wherein:

12 the secondary data mover computer is programmed for using the clock time as a
13 first file-modification time by acknowledging the first asynchronous write request from
14 the client by returning to the client the clock time as the time when the file was modified
15 by the first asynchronous write operation, and

16 the secondary data mover computer is programmed for acknowledging the second
17 asynchronous write request from the client by returning to the client the second file-
18 modification time as the time when the file was modified by the second asynchronous
19 write operation.

20

21 47. The network file server as claimed in claim 44, wherein the secondary data mover
22 computer is programmed for responding to a request from the client to commit results of

1 the second asynchronous write operation by sending a flush request to the primary data
2 mover computer, the flush request including the second file-modification time.

3

4 48. The network file server as claimed in claim 47, wherein the primary data mover
5 computer is programmed for sending the second file-modification time to other clients
6 caching attributes for the file.

7

8 49. The network file server as claimed in claim 44, wherein the secondary data mover
9 computer is programmed for receiving from the primary data mover computer an updated
10 value for the file-modification time for the file after the secondary data mover computer
11 has completed the first asynchronous write operation, for comparing the updated value
12 for the file-modification time for the file to last value determined by the secondary data
13 mover for the file-modified time for the file, and upon finding that the updated value for
14 the file-modification time for the file is greater than the last value determined by the
15 secondary data mover for the file-modified time for the file, for resetting the timer, using
16 the updated value for the file-modification time for the file in lieu of the clock time
17 having been obtained from the primary data mover computer, and using the updated
18 value for the file-modified time for the file as the most recent value for the file-
19 modification time for the file.

20

21 50. The network file server as claimed in claim 44, wherein the secondary data mover
22 computer is programmed for receiving from the primary data mover computer an updated
23 value for the file-modification time for the file after the secondary data mover computer

1 has completed the first asynchronous write operation, for comparing the updated value
2 for the file-modification time for the file to last value determined by the secondary data
3 mover for the file-modified time for the file, and upon finding that the updated value for
4 the file-modification time for the file is less than the last value determined by the
5 secondary data mover for the file-modified time for the file, for ignoring the updated
6 value for the file-modification time for the file.